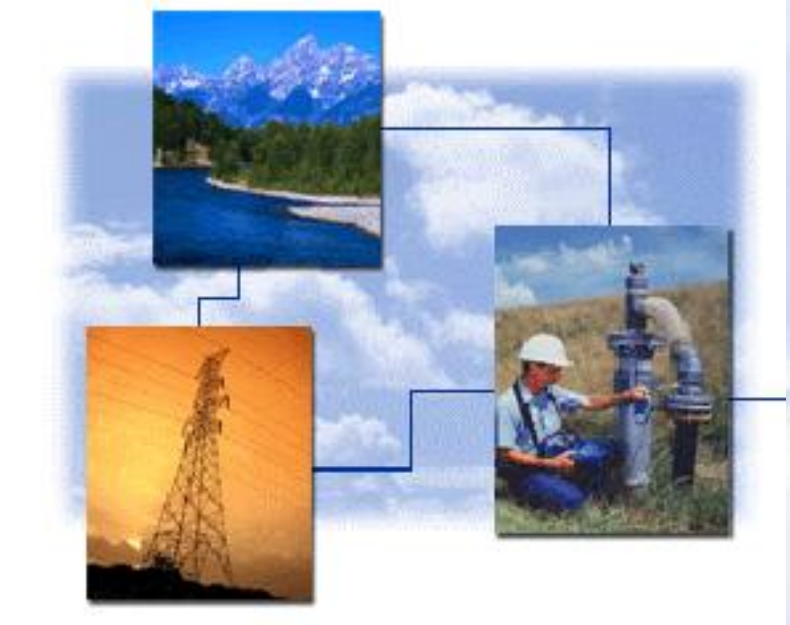
An Overview of Landfill Gas Energy in the United States



U.S. Environmental Protection Agency
Landfill Methane Outreach Program (LMOP)

LANDFILL METHANE OUTREACH PROGRAM

File Last Updated: April 2006

Why EPA Cares About Landfill Gas

- Methane is a potent heat-trapping gas
- Landfills are the largest human-made source of methane in the United States
- There are many cost-effective options for reducing methane emissions while generating energy
- Projects reduce local air pollution and create jobs, revenues, and cost savings

EPA's Landfill Methane Outreach Program

- Established in 1994
- Voluntary program that creates alliances among states, energy users/providers, the landfill gas industry, and communities

Mission: To reduce methane emissions by lowering barriers and promoting the development of cost-effective and environmentally beneficial landfill gas energy (LFGE) projects.

File Last Updated: April 2006

Modern Municipal Solid Waste Landfill

LANDFILL METHANE OUTREACH PROGRAM

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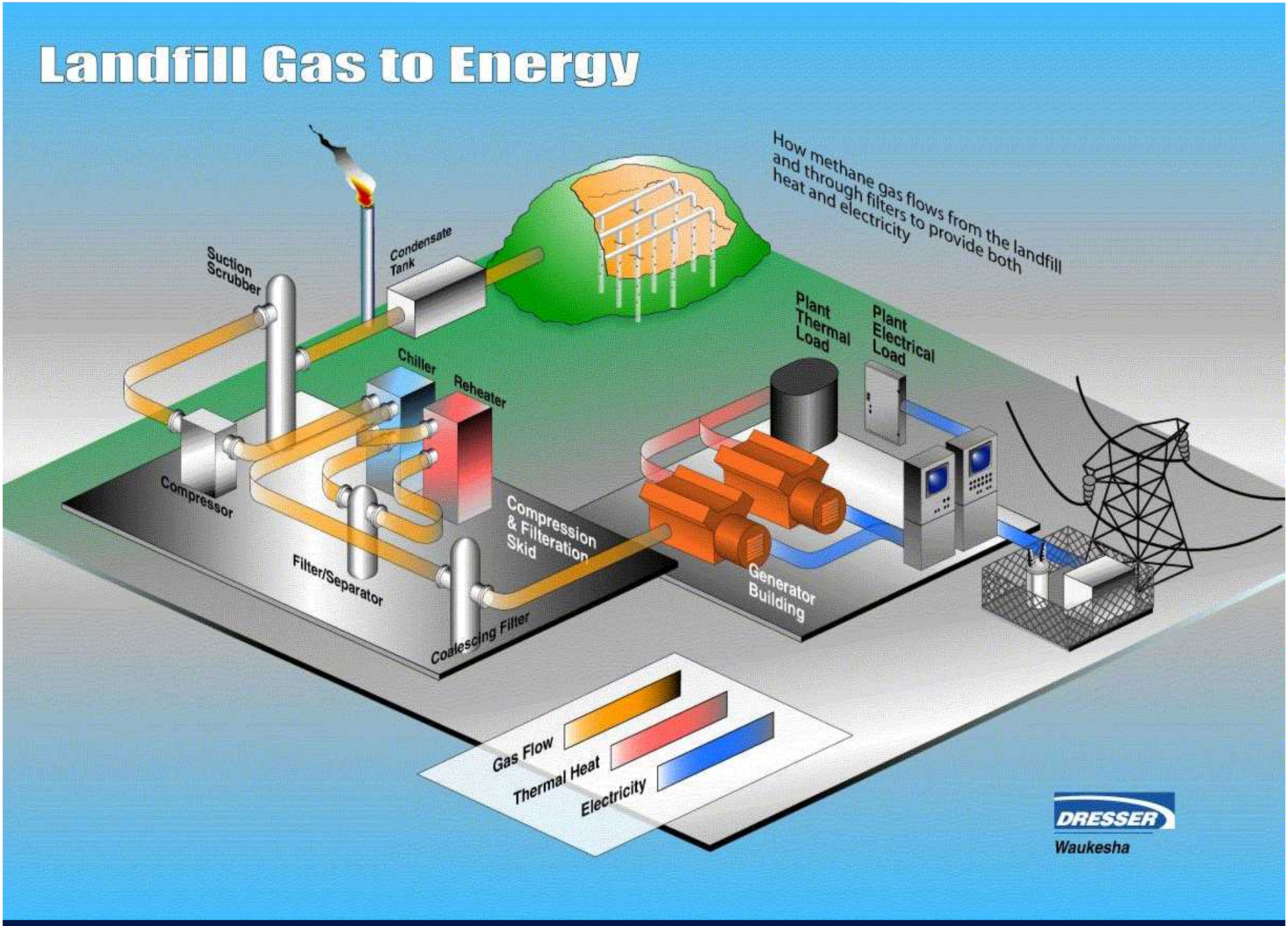
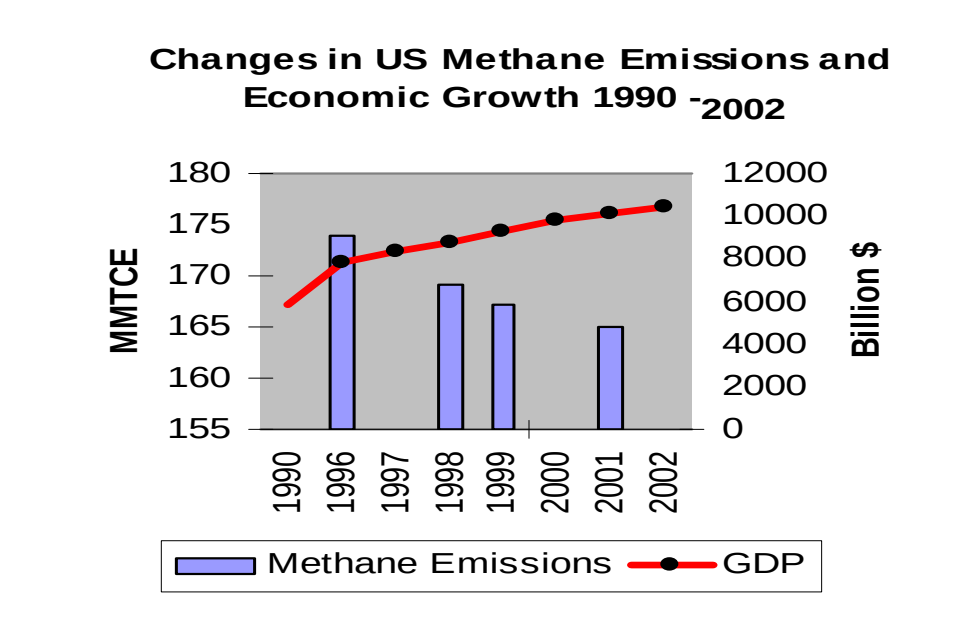
Landfill Gas 101

- Landfill gas (LFG) is a by-product of the decomposition of municipal solid waste (MSW)
- LFG:
  - ~ 50% methane (CH_4)
  - ~ 50% carbon dioxide (CO_2)
  - <1% non-methane organic compounds (NMOCs)
- For every 1 million tons of MSW:
  - ~ 0.8 MW of electricity
  - ~ 432,000 cubic feet per day of LFG
- If uncontrolled, LFG contributes to smog and global warming, and may cause health and safety concerns


Landfill Gas to Energy
How methane gas flows from the landfill and through filters to provide both heat and electricity
Suction Scrubber
Condensate Tank
Chiller
Reheater
Compressor
Filter/Separator
Compression & Filteration Skid
Coalescing Filter
Plant Thermal Load
Plant Electrical Load
Generator Building
Gas Flow
Thermal Heat
Electricity
DRESSER
Waukesha

Targeting Methane…Producing Measurable Results

- *U.S. Methane Emissions 10% Below 1990 Level*



"Looking to likely emissions over the next half century, it is also the case that feasible reductions in emissions of methane and other non-CO_2 gases can make a contribution to slowing global warming that is as large or even larger than similar reductions in CO_2 emissions." -- MIT, 2003

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LFG Has Been Used to Help Produce…

- Aquaculture (e.g., Tilapia)
- Biodiesel
- Biosolids (drying)
- Bricks and concrete
- Carpet
- Cars and trucks
- Chemicals
- Chocolate
- Consumer goods and containers
- Denim
- Electronics
- Fiberglass, nylon and paper
- Furthering space exploration
- Garden plants
- Green power
- Infrared heat
- LNG/CNG vehicle fuel
- Orange and apple juice
- Pharmaceuticals
- Pierogies and snack food
- Pottery and glass
- Soy-based products
- Steel
- Tomatoes (hydroponic)
- Taxpayer savings and increased sustainability!

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Landfill Gas and Green Power
A Winning Combination

- Dual benefit ➡ destroys methane and other organic compounds in LFG
- Offsets use of nonrenewable resources (coal, oil, gas) reducing emissions of
  - SO_2 , NO_X , PM, and CO_2
- LFGE is a recognized renewable energy resource
  - *Green-e*, EPA Green Power Partnership, Sierra Club, NRDC
- LFG is generated 24/7 and projects have online reliability over 90%
- LFG can act as a long-term price and volatility hedge against fossil fuels

Total Levelized Cost of Generating Technologies

	Wind		Solar Photovoltaic		Geothermal	Landfill Gas
Vintage	**2005**	**2015**	**2005**	**2015**	**(all vintages)**	**(all vintages)**
All In Capital ($/kW)	**1,199**	**1,141**	**3,075**	**2,661**	**2,536**	**1,268**
Plant Costs	980	925	2,733	2,346	2,229	**1,044**
Interconnection Cost	141	141	141	141	141	**141**
Interest During Construction (7% = 6% Interest + 1% Bank Fees)	78	75	201	174	166	**83**
Total O&M	**25.50**	**25.50**	**10.00**	**10.00**	**127.62**	**166.05**
Fixed O&M ($/kw/yr)	25.50	25.50	10.00	10.00	120.00	**47.00**
Variable O&M ($/kw/yr)	0.00	0.00	0.00	0.00	7.62	**119.05**
Capacity Factor	**32.0%**	**36.5%**	**30%**	**30%**	**87%**	**90%**
Reserve Margin Contribution	20%	20%	50%	50%	100%	**100%**
Capital Charge Rate	12%	12%	12%	12%	11%	**15%**
Levelized Average All-In Generation Cost ($/MWh)	**59.16**	**49.71**	**140.71**	**122.28**	**54.34**	**45.67**
Levelized Production Tax Credit ($/MWh)	10.71	10.71	0.00	0.00	0.00	**0.00**
Tax Adjusted Levelized Generation Cost ($/MWh)	**48.45**	**39.00**	**140.71**	**122.28**	**54.34**	**45.67**

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Jobs and Revenue Creation - National

- A typical 3 MW LFG electricity project is estimated to have the following national benefits (direct, indirect, and induced) during the construction year:
  - Increase the output of the U.S. economy by more than $10 million
  - Increase U.S. employee earnings by more than $3.0 million (wages, salaries, etc.)
  - Employ more than 70 people (expressed in full-time equivalents per year)

State of the National LFGE Industry (2/06)

- At least 400 operational projects in 40 states supplying:
  - 9 billion kilowatt hours of electricity and 74 billion cubic feet of landfill gas to direct-use applications in 2005
- Estimated **Annual** Environmental Benefits:
  - Planting nearly 19,000,000 acres of forest, or
  - Preventing the use of over **160,000,000 barrels of oil**, or
  - Removing emissions equivalent to over **13,000,000 vehicles**, and
  - Powering over **725,000 homes** and heating nearly **1,200,000 homes.**

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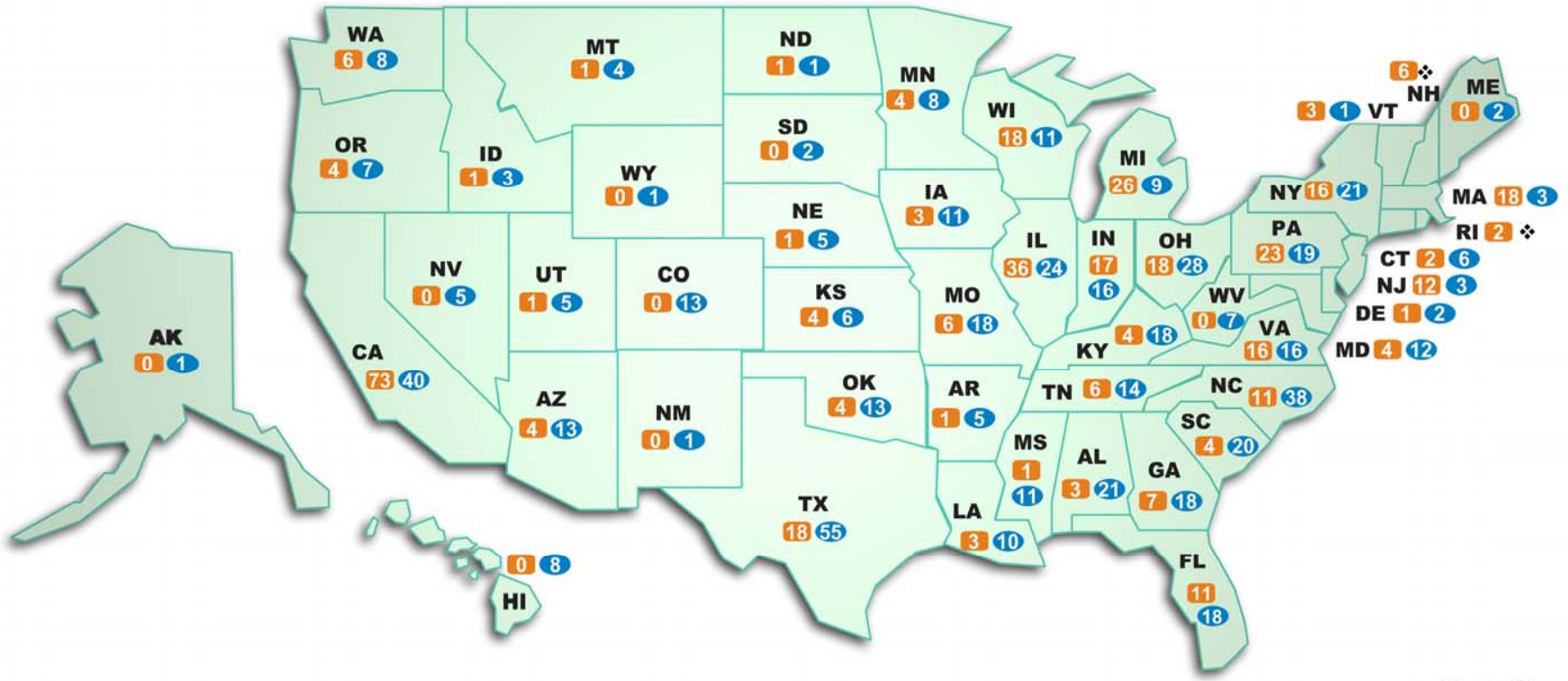
Status of LFGE Project Development and Candidate Landfills by State



Nationwide Summary
400 OPERATIONAL Projects
~600 CANDIDATE Landfills have 17 MMTCE Potential

OPERATIONAL PROJECTS

CANDIDATE LANDFILLS

These data are from LMOP's database as of April 18, 2006.

❖LMOP does not have any information on candidate landfills in this state.

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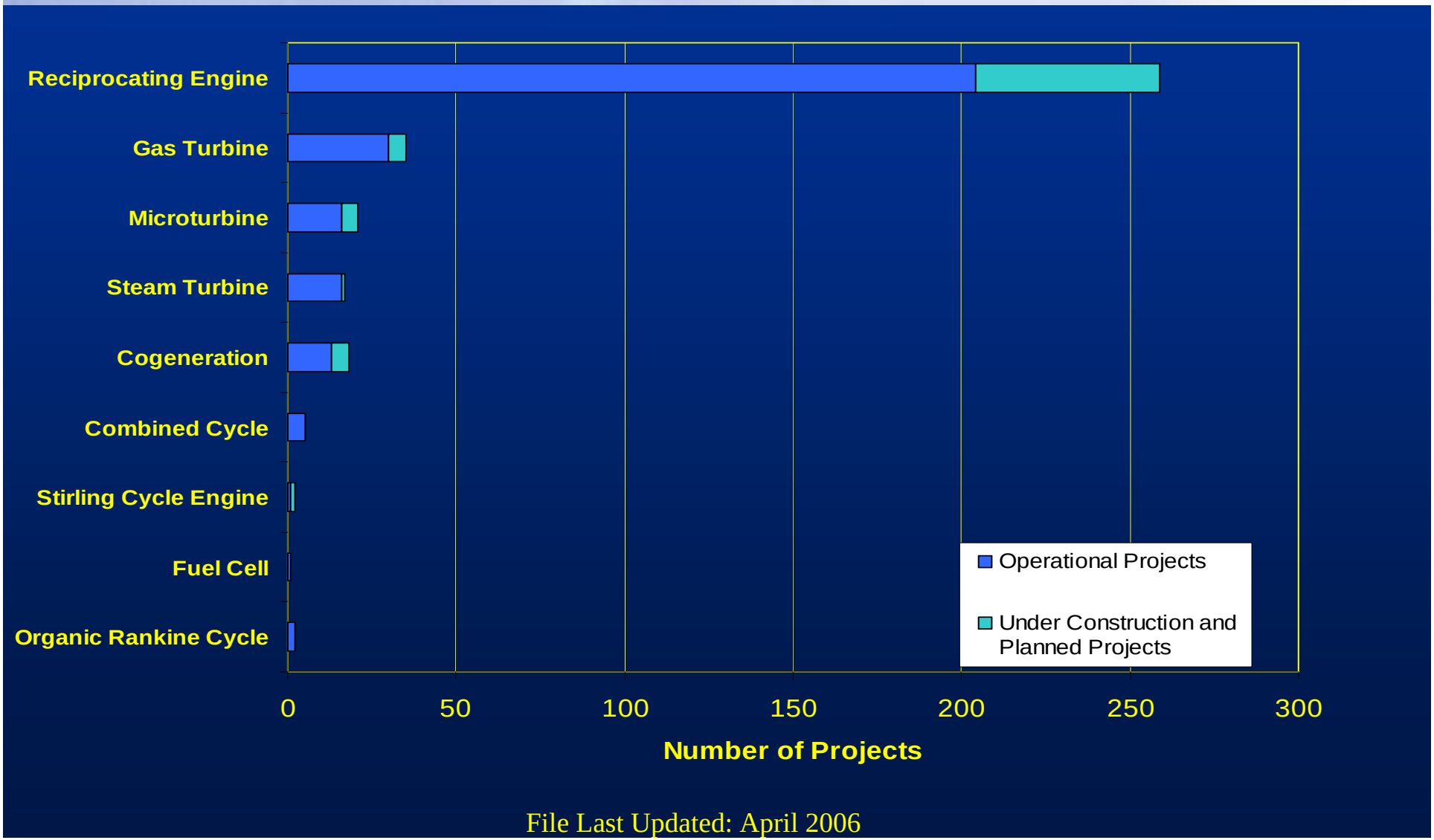
Technology Trends
Electricity Projects



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Diversity of Project Types
Electricity Generation

LANDFILL METHANE OUTREACH PROGRAM

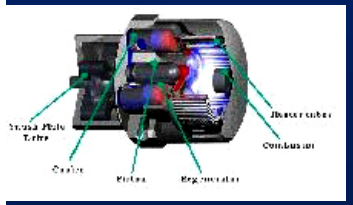
Internal Combustion Engine

Gas Turbine

Emerging Technologies

Microturbine

Organic Rankine Cycle Engine



Stirling "External Combustion" Engine

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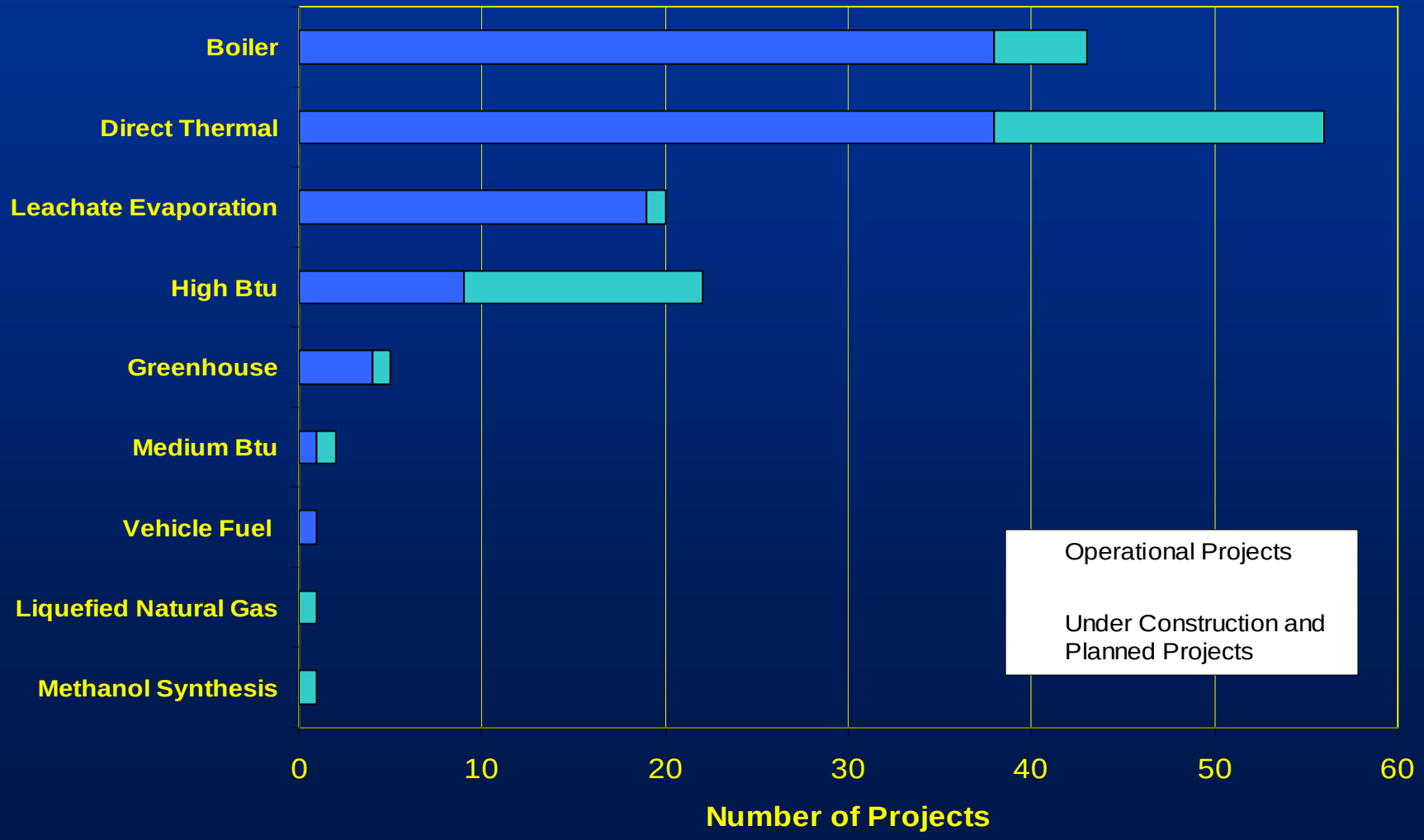
Technology Trends
Direct-Use Projects



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Diversity of Project Types
Direct-Use of LFG

- Direct-use projects are growing!
  - Boiler applications - replace natural gas, coal, fuel oil
  - Combined heat & power (CHP)
  - Direct thermal (dryers, kilns)
  - Natural gas pipeline injection
    - Medium and high Btu
  - Greenhouse
  - Leachate evaporation
  - Vehicle fuel (LNG)
  - Artist studios
  - Hydroponics
  - Aquaculture (fish farming)

Greenhouse Burlington, NJ

Pottery Studio Sugar Grove, NC

LFG-fired Boiler Ft. Wayne, IN

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Emerging Technologies: *LFG for Vehicle Fuel*

LANDFILL METHANE OUTREACH PROGRAM

- City of Denton, TX used its LFG to fuel a 3 million gal/yr biodiesel production facility
- Puente Hills Landfill uses LFG for compressed natural gas (CNG) to fuel landfill equipment
- Central Landfill in CA plans to use LFG to CNG to fuel Sonoma County Transit buses

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Regulations that Affect LFGE

- LFGE projects are affected by a variety of federal, state, and local air quality regulations:
  - NSPS;
  - Title V;
  - Maximum Achievable Control Technology (MACT);
  - New Source Review (NSR); and
  - Prevention of Significant Deterioration (PSD)

Landfill Gas and State Renewable Portfolios

- Renewable Portfolio Standard (RPS) - requires utilities to supply a percentage of power from renewable sources
  - 19 states plus District of Columbia have an RPS
- Renewable Portfolio Goal (RPG) - same as RPS but an objective instead of a requirement
  - 3 states have an RPG
- LFG is eligible as a renewable source for all 22 states and District of Columbia

File Last Updated: April 2006

Landfill Gas and RECs

- Renewable Energy Credits (RECs)
- Companies looking to reduce environmental footprint purchase RECs from utilities using LFG
  - DuPont - 170 million kWh from biomass and LFG
  - Pitney Bowes - 10% of electricity from wind and LFG
  - Staples - 46 million kWh/year of RECs, 90% from biomass and LFG

Emissions Trading of Landfill Gas

- Chicago Climate Exchange (CCX) is a voluntary GHG reduction and trading program
  - Offers a credit of 18.25 metric tons CO_2 per metric ton of methane combusted
  - Applicable for LFG collection and combustion systems placed into service after 12/31/98
  - Prices range from $1 to $3.25 per metric ton
  - Only landfills not required by federal law (e.g., NSPS) to combust LFG are eligible
  - Landfill methane emission offsets brochure at www.chicagoclimateexchange.com

Federal Financial Incentives

- Section 45 Tax Credit
  - Electricity generation - 0.9 cents/kWh
  - Placed in service by 12/31/07
  - 5- or 10-year window for credits depending on placed-in-service date
- Section 29 Tax Credit (re-designated as Section 45K)
  - Both direct-use and electricity generation
  - Effective for taxable years ending after 12/31/05
- Renewable Energy Production Incentive (REPI)
  - Local/state government or non-profit electric co-op facilities
  - Online by 10/1/16
  - Payment for first 10 years of operation

Landfill Gas Energy: Negative Perceptions

- 'Zero Waste' concerns
  - "Environmental groups have been wary of using landfill gas to generate electricity, because they want to encourage recycling, not trash disposal."
  - *"But it is better to use landfill methane than to waste it…It's got a nice je ne sais quoi to it."*

    -- Nathanael Greene, NRDC

Look Who's Using Landfill Gas

Honeywell

DAIRYLAND POWER COOPERATIVE

NUCOR

The Solae Company

Owens Corning

CONE corporatedenimfinishingjacquards

HILL AIR FORCE BASE, Utah
OGDEN AIR LOGISTICS CENTER

GE

Frito Lay

Cargill

Rolls-Royce

SENECA Foods.com "A World Leader In Agribusiness"

SC Johnson

INTERNATIONAL

Ford

DUPONT The miracles of science

SUNOCO

LAFARGE

INTERFACE

AJINOMOTO

GM

Nestlé Makes the Very Best

MALLINCKRODT

NASA

BMW The Ultimate Driving Machine

Lucent Technologies Bell Labs Innovations

INTERNATIONAL PAPER From innovation to results.

DAIMLERCHRYSLER

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Direct-Use Case Study
Lanchester LF, Narvon, PA

- First LFGE project in PA to serve multiple customers – will eventually provide LFG to 4 direct end users
- Battle won: not regulated by PUC as a public utility!
- 13-mile pipeline through 75 easements and 35 road crossings

2005 LMOP Award Winner

File Last Updated: April 2006

Direct-Use Case Study
Lanchester LF, Narvon, PA
(cont.)

LANDFILL METHANE OUTREACH PROGRAM

- Two end users already using LFG in boilers, thermal oxidizers, & ovens
- LFG fuels transport of itself – self-reliant project
- Estimated annual savings of $300,000 in avoided electricity costs

- Public and Private Partnerships
  - Granger Energy, Chester County Solid Waste Authority, & PA DEP overcame economic & technical difficulties

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Direct-Use Case Study

City of Denton Landfill, TX and Biodiesel Industries

LANDFILL METHANE OUTREACH PROGRAM

- One renewable fuel 'fuels' another…
- LFG from city landfill used in industrial process to convert renewable feedstock, vegetable oils, and animal fats into 3 million gal/yr of biodiesel
- City garbage trucks and other utility vehicles are fueled by 80% diesel/ 20% biodiesel (B20)
  - Improves regional air quality
  - Stimulates local economic development
  - Reduces dependence on foreign oil

2005 LMOP Award Winner

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CHP Case Study

H_2Gro Greenhouses
Lewiston, NY

- Innovative Energy Systems' Model City Energy Facility at the Modern Landfill went online June 1, 2001
- 5.6 MW capacity from 7 Caterpillar G3516 engine-generator sets
- Provides all electrical and heating requirements of H_2Gro Greenhouses
- Excess electricity sold to grid
- H_2Gro initially constructed a ½ acre hydroponic greenhouse test cell and yielded 180,000 lb/yr of tomatoes
- H_2Gro has since expanded to 7½ acres and produces 10,000 lb/day or 3.5 million lb/yr of tomatoes

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There Are Still Many Untapped LFG Resources

- Currently ~600 candidate landfills with a total gas generation potential of 725 million cubic feet per day or ~15,000 MMBtu/hr
- Total expected annual environmental benefits if all projects were developed/ producing power:
  - Planting 15 million acres of forest, or
  - Removing the emissions from over 10.5 million vehicles on the road, or
  - Powering 900,000 homes per year

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LMOP Partner Tools and Services

- Partnerships and networking (over 500)
- Newsletter and listserv
- Direct Project Assistance
  - Feasibility studies, end user searches
- Technical Assistance Resource
- LFG Advocate
- PR/Ribbon Cuttings

GM and Toro Energy
Ribbon-Cutting Ceremony

May 2002

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LMOP Partner Recruitment Tools and Services

- Project and Candidate Database
- Green Pricing Accreditation Involvement
- State Workshops/Conferences
  - Working with State Partners and SWANA
- Peer Matching
- Web Site (e.g., publications, database)
- *Annual LMOP Conference, Project Expo, and Partner Awards* – Baltimore, MD

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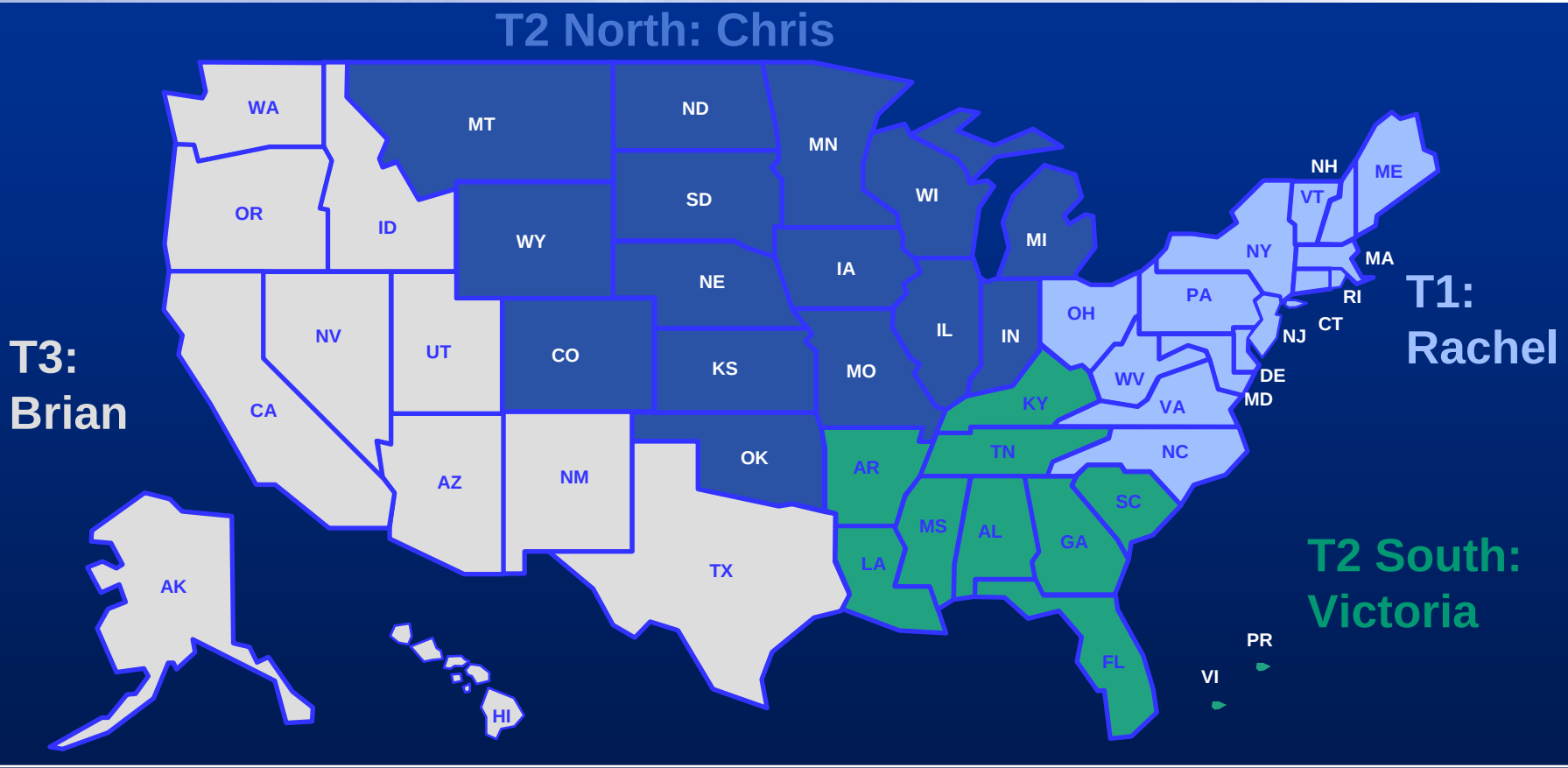
For More Information

www.epa.gov/lmop - LMOP Hotline: 888-782-7937

LANDFILL METHANE OUTREACH PROGRAM



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